TITLE: CONTINUOUS DATA BACKUP USING DISTRIBUTED JOURNALING
Inventors: Fernando Oliveira, et al.
Serial No.: To Be Assigned Filed: March 16, 2004 EMS-07301
Agent: Anne E. Saturnelli Reg. No.: 41,290 **Sheet 1 of 17**

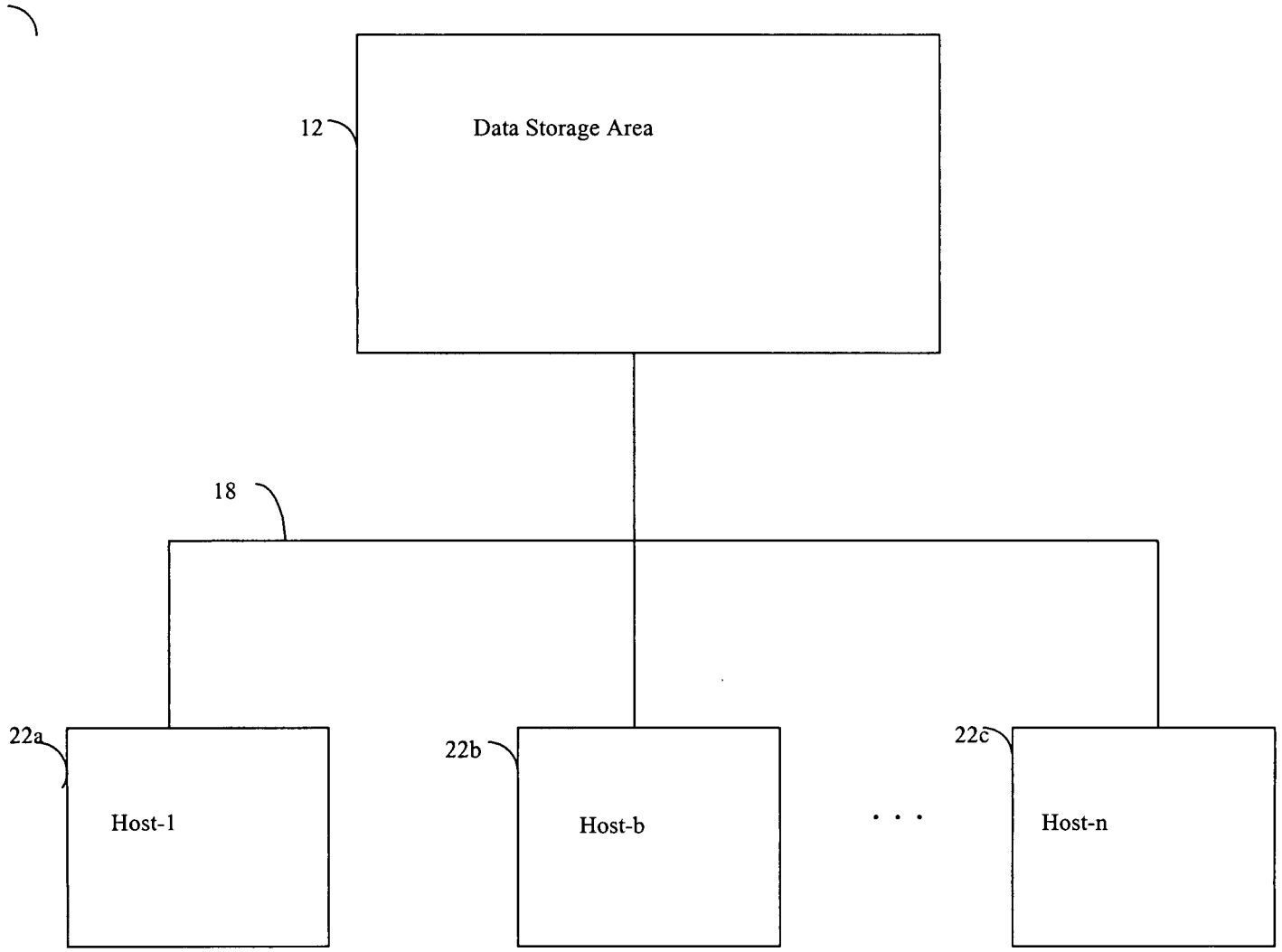


FIGURE 1

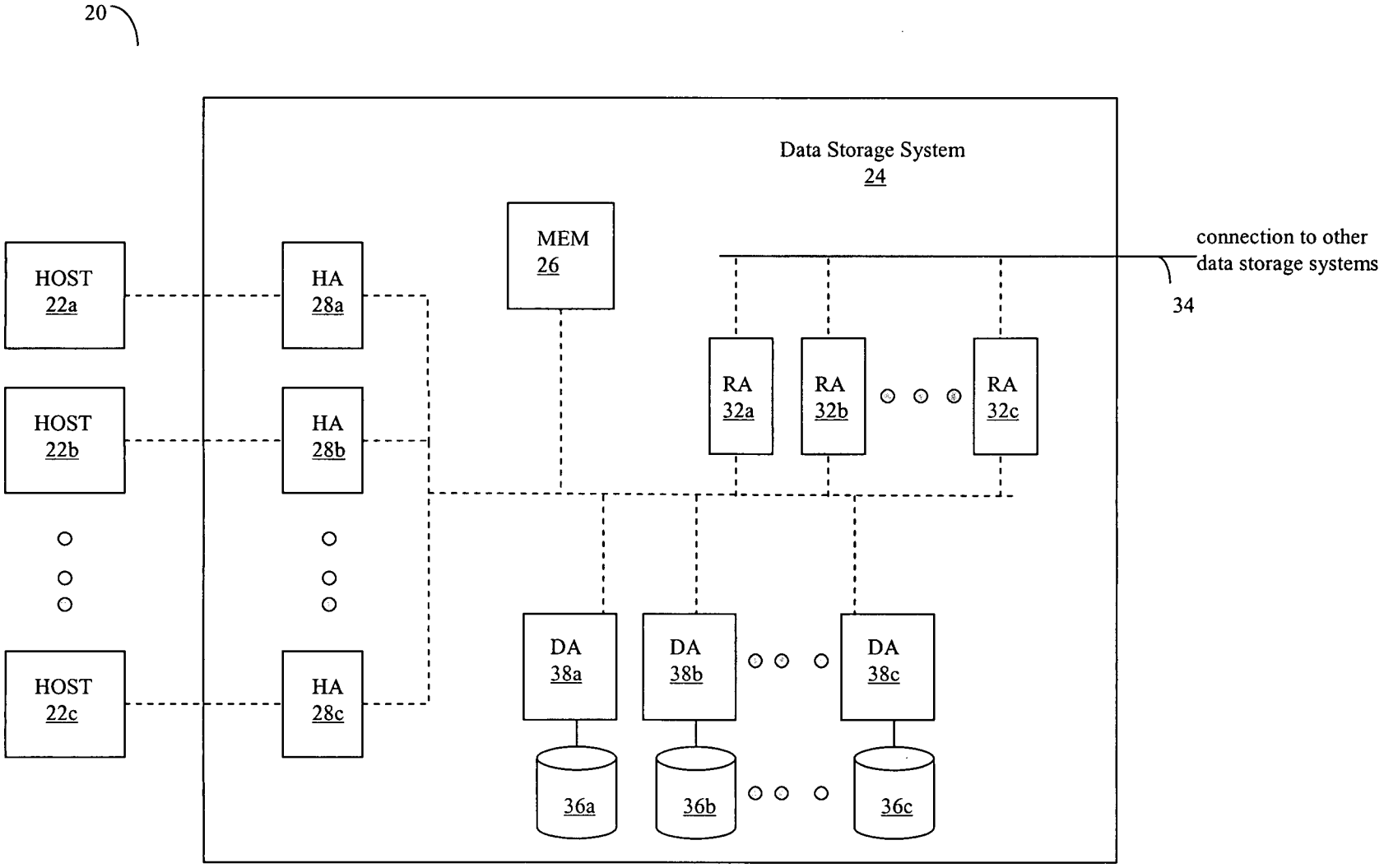

20
Data Storage System
24
MEM
26
connection to other
data storage systems
34
HOST
22a
HOST
22b
HOST
22c
HA
28a
HA
28b
HA
28c
RA
32a
RA
32b
RA
32c
DA
38a
DA
38b
DA
38c
36a
36b
36c

FIGURE 2

FIGURE 3

100
Server 1
102a
Server n
102n
Switch 104
Storage System
106a
Storage System
106n

FIGURE 4A

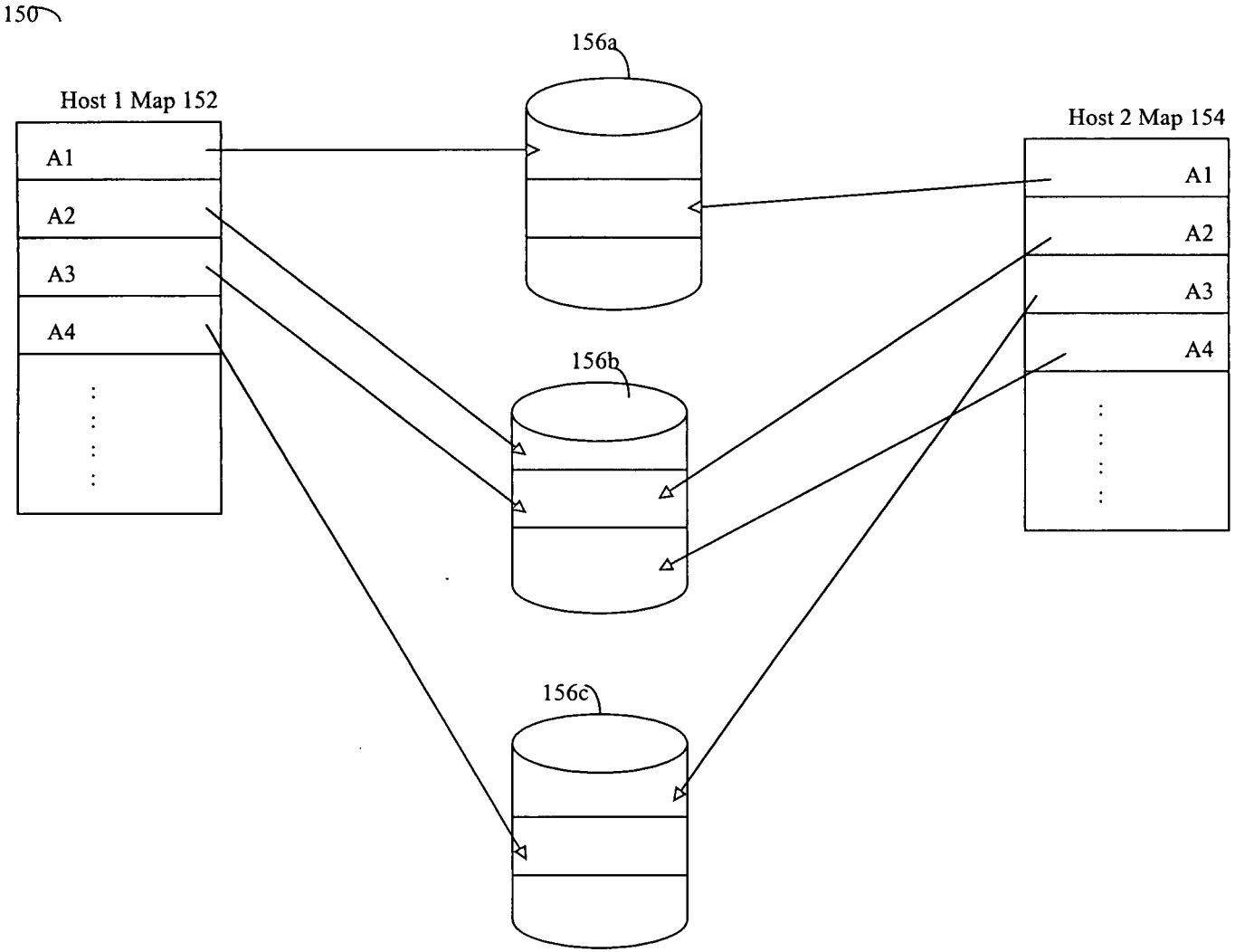

150
Host 1 Map 152
A1
A2
A3
A4
156a
156b
156c
Host 2 Map 154
A1
A2
A3
A4

FIGURE 4B

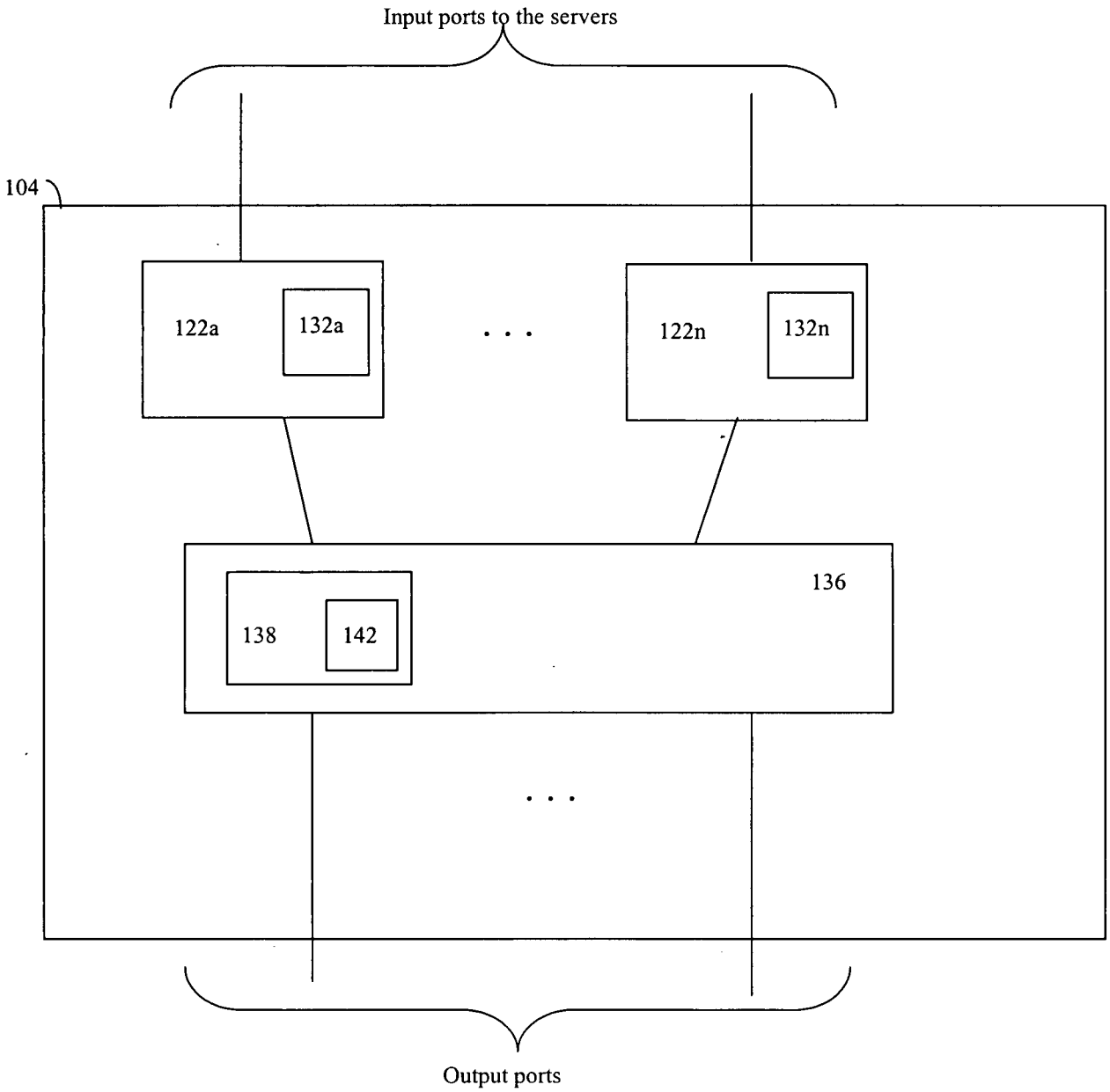

Input ports to the servers
104
122a
132a
122n
132n
136
138
142
Output ports

FIGURE 5

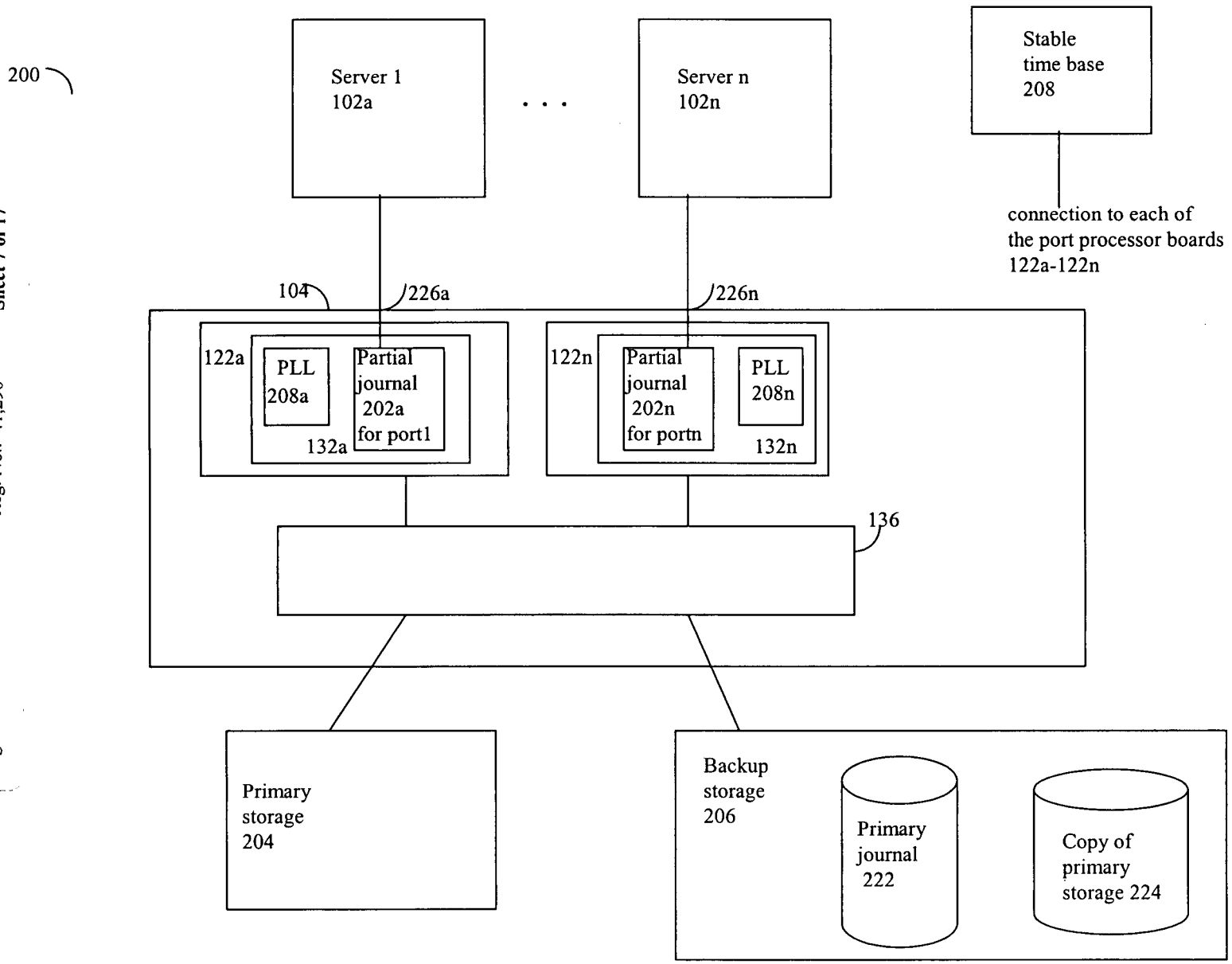

200
Server 1
102a
Server n
102n
Stable
time base
208
connection to each of
the port processor boards
122a-122n
104
226a
226n
122a
PLL
208a
Partial
journal
202a
for port1
132a
122n
Partial
journal
202n
for portn
PLL
208n
132n
136
Primary
storage
204
Backup
storage
206
Primary
journal
222
Copy of
primary
storage 224

FIGURE 6

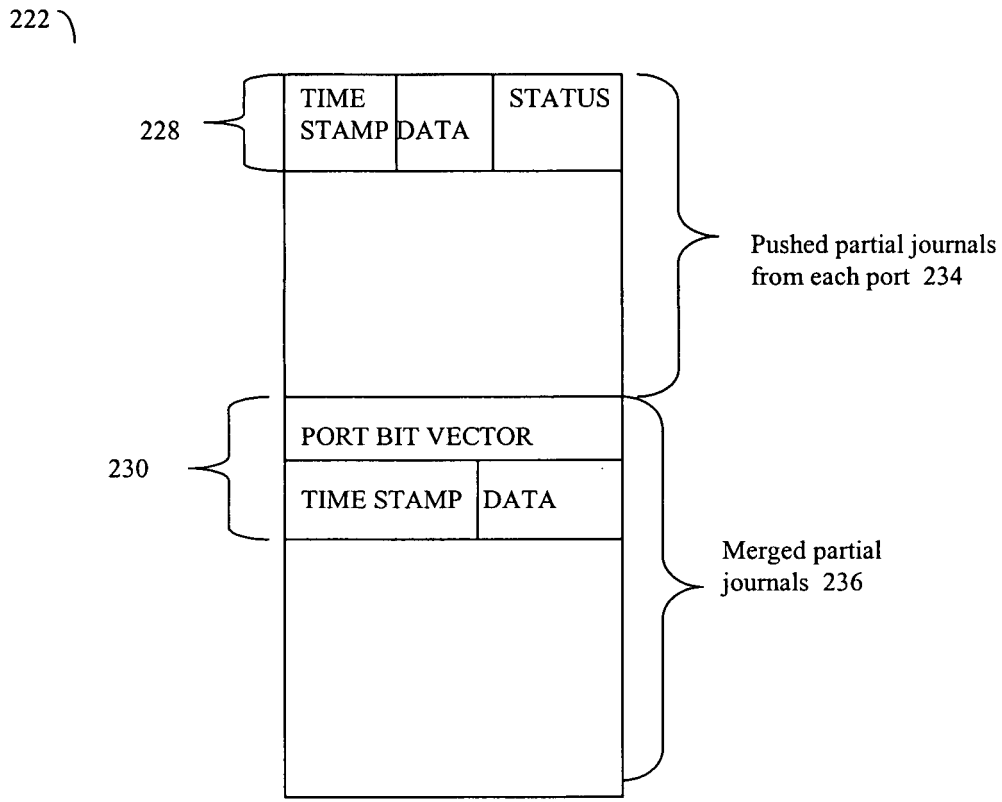

222
228
TIME STAMP
DATA
STATUS
Pushed partial journals from each port 234
230
PORT BIT VECTOR
TIME STAMP
DATA
Merged partial journals 236

FIGURE 7

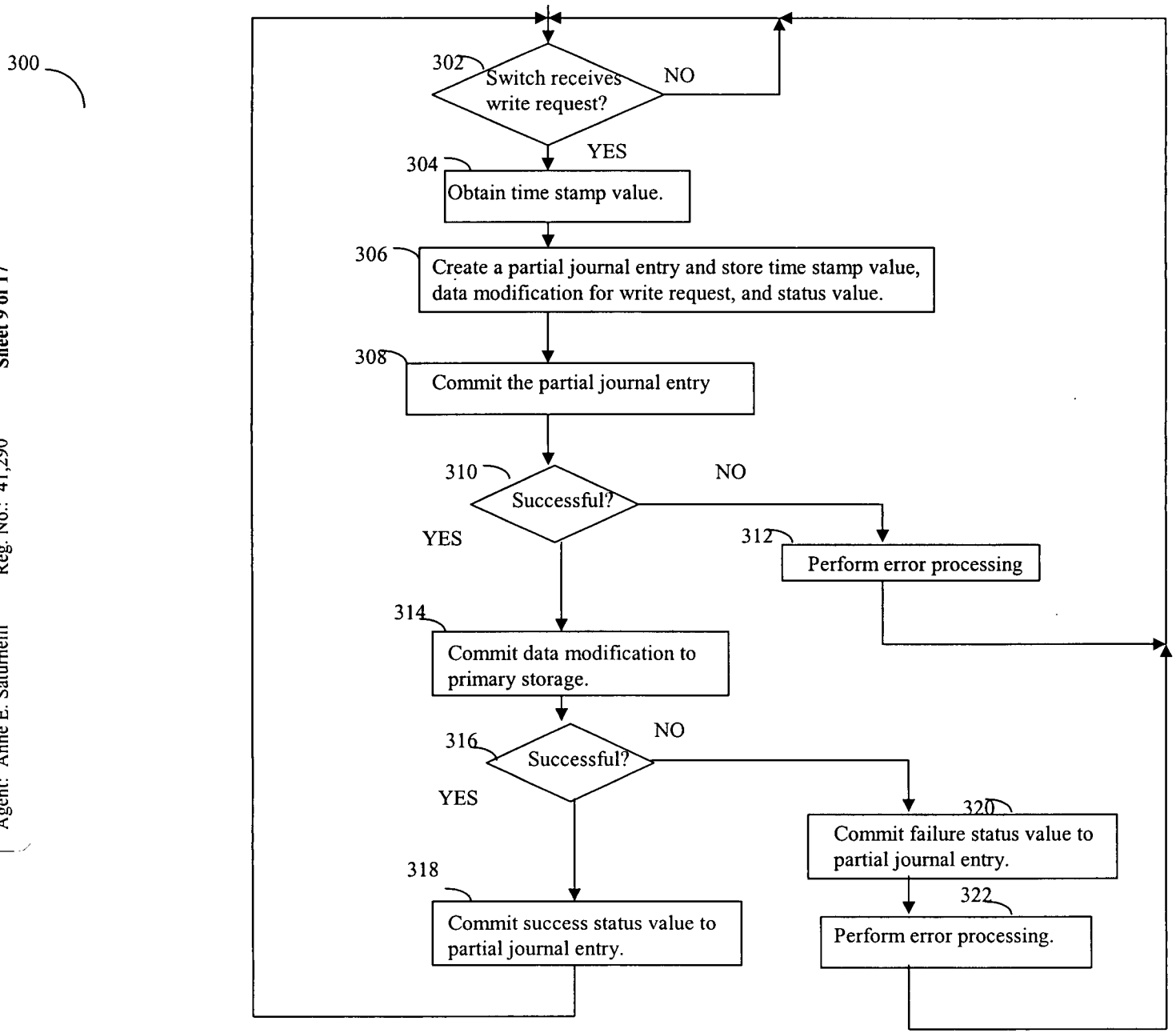

300
302
Switch receives write request?
NO
YES
304
Obtain time stamp value.
306
Create a partial journal entry and store time stamp value, data modification for write request, and status value.
308
Commit the partial journal entry
310
Successful?
NO
YES
312
Perform error processing
314
Commit data modification to primary storage.
316
Successful?
NO
YES
320
Commit failure status value to partial journal entry.
318
Commit success status value to partial journal entry.
322
Perform error processing.

FIGURE 8

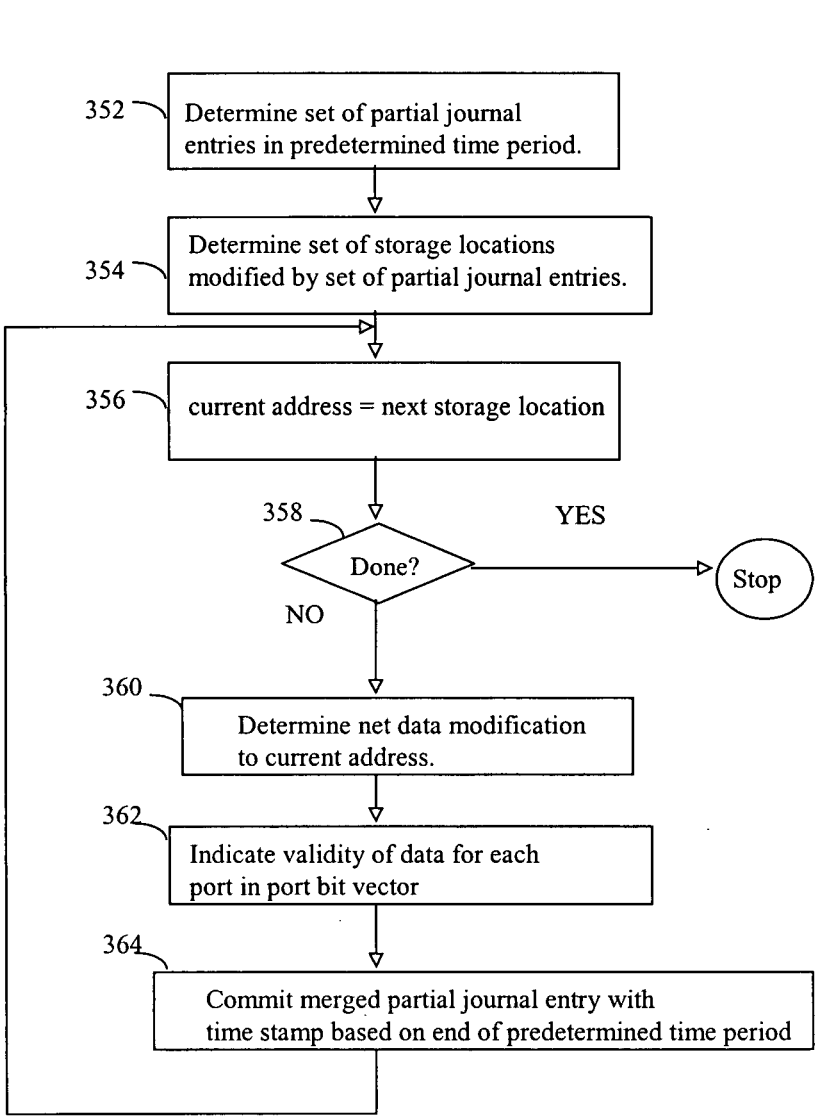

350
352
Determine set of partial journal entries in predetermined time period.
354
Determine set of storage locations modified by set of partial journal entries.
356
current address = next storage location
358
Done?
YES
Stop
NO
360
Determine net data modification to current address.
362
Indicate validity of data for each port in port bit vector
364
Commit merged partial journal entry with time stamp based on end of predetermined time period

FIGURE 9

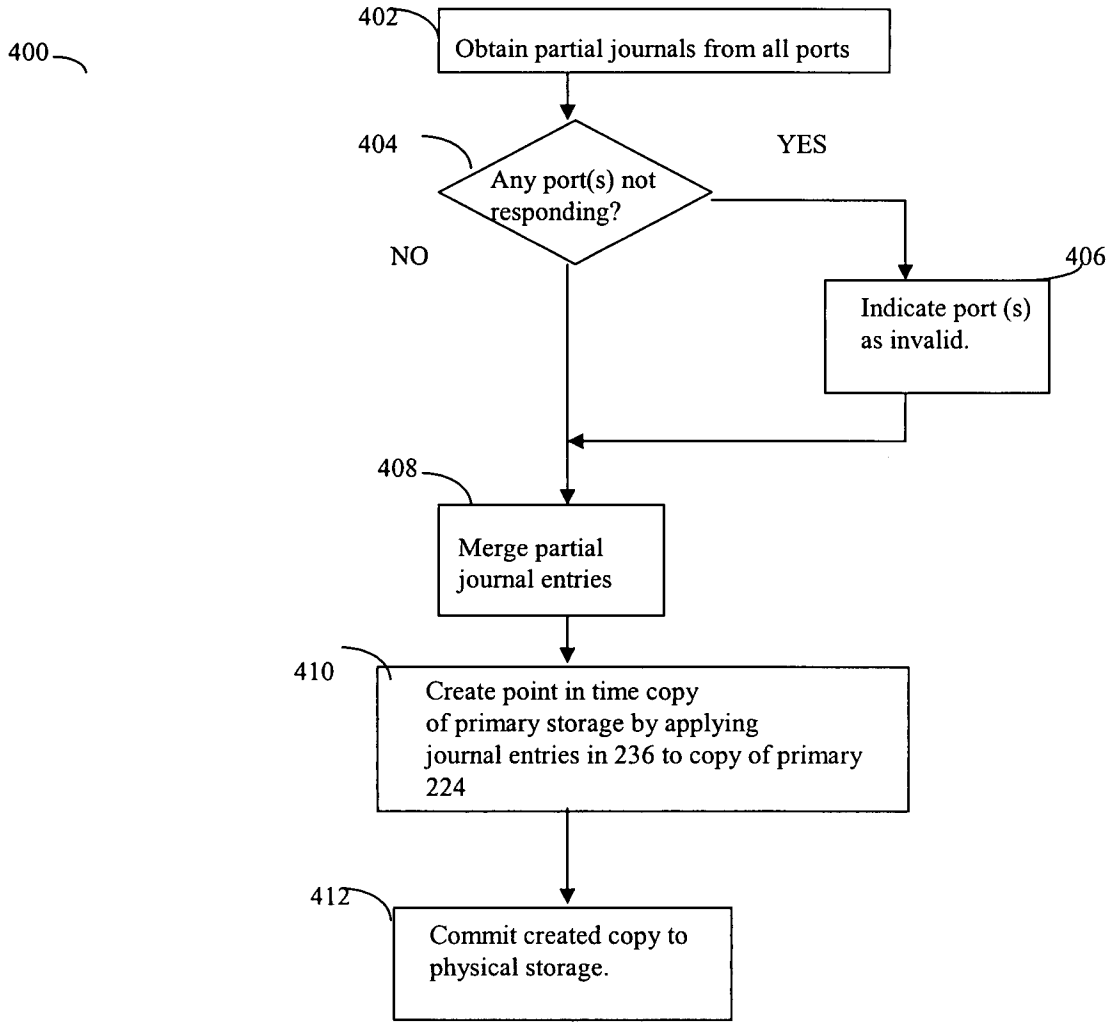

400
402
Obtain partial journals from all ports
404
Any port(s) not responding?
YES
NO
406
Indicate port (s) as invalid.
408
Merge partial journal entries
410
Create point in time copy of primary storage by applying journal entries in 236 to copy of primary 224
412
Commit created copy to physical storage.

FIGURE 10

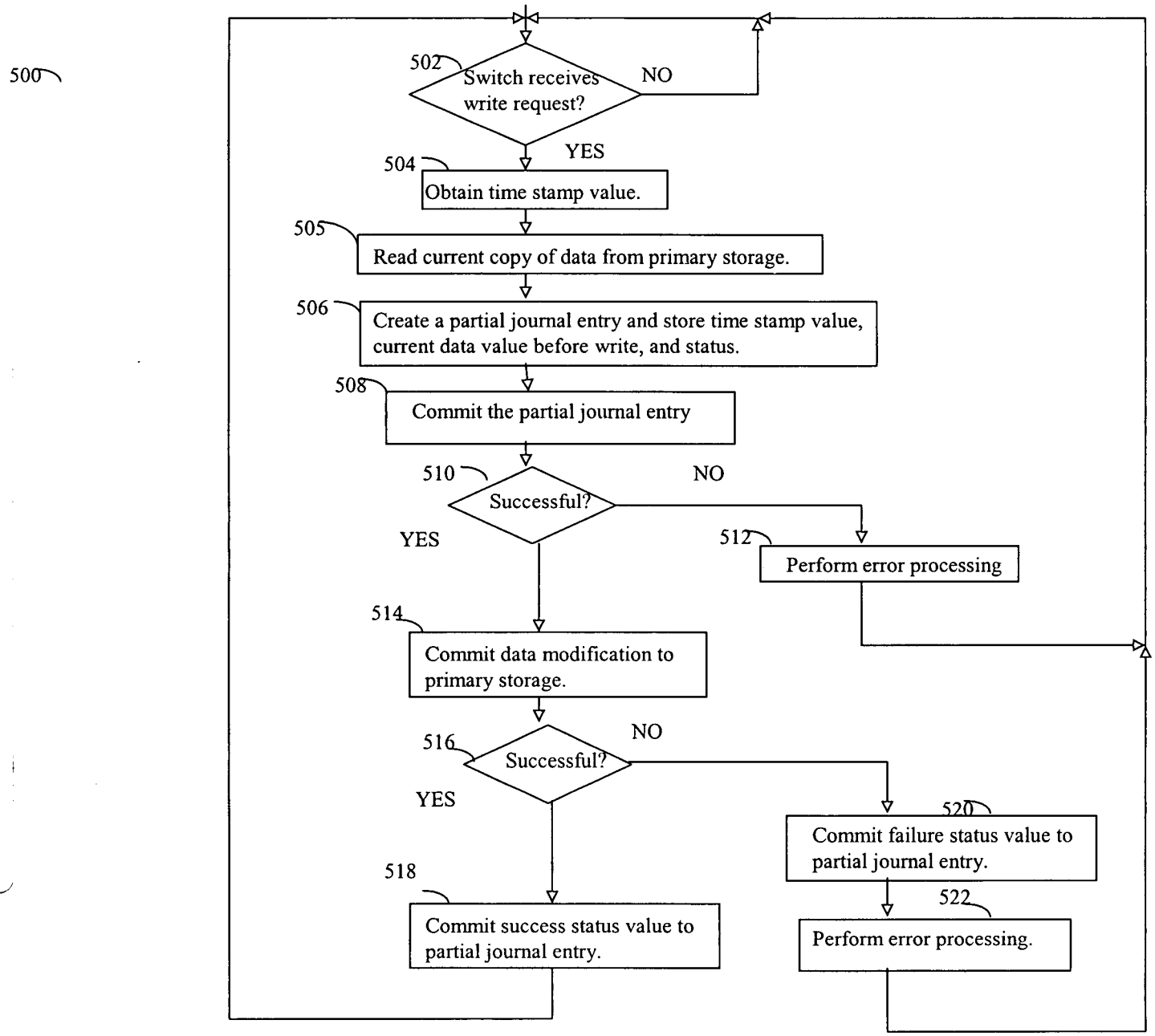

500
502
Switch receives write request?
NO
YES
504
Obtain time stamp value.
505
Read current copy of data from primary storage.
506
Create a partial journal entry and store time stamp value, current data value before write, and status.
508
Commit the partial journal entry
510
Successful?
NO
YES
512
Perform error processing
514
Commit data modification to primary storage.
516
Successful?
NO
YES
520
Commit failure status value to partial journal entry.
522
Perform error processing.
518
Commit success status value to partial journal entry.

FIGURE 11

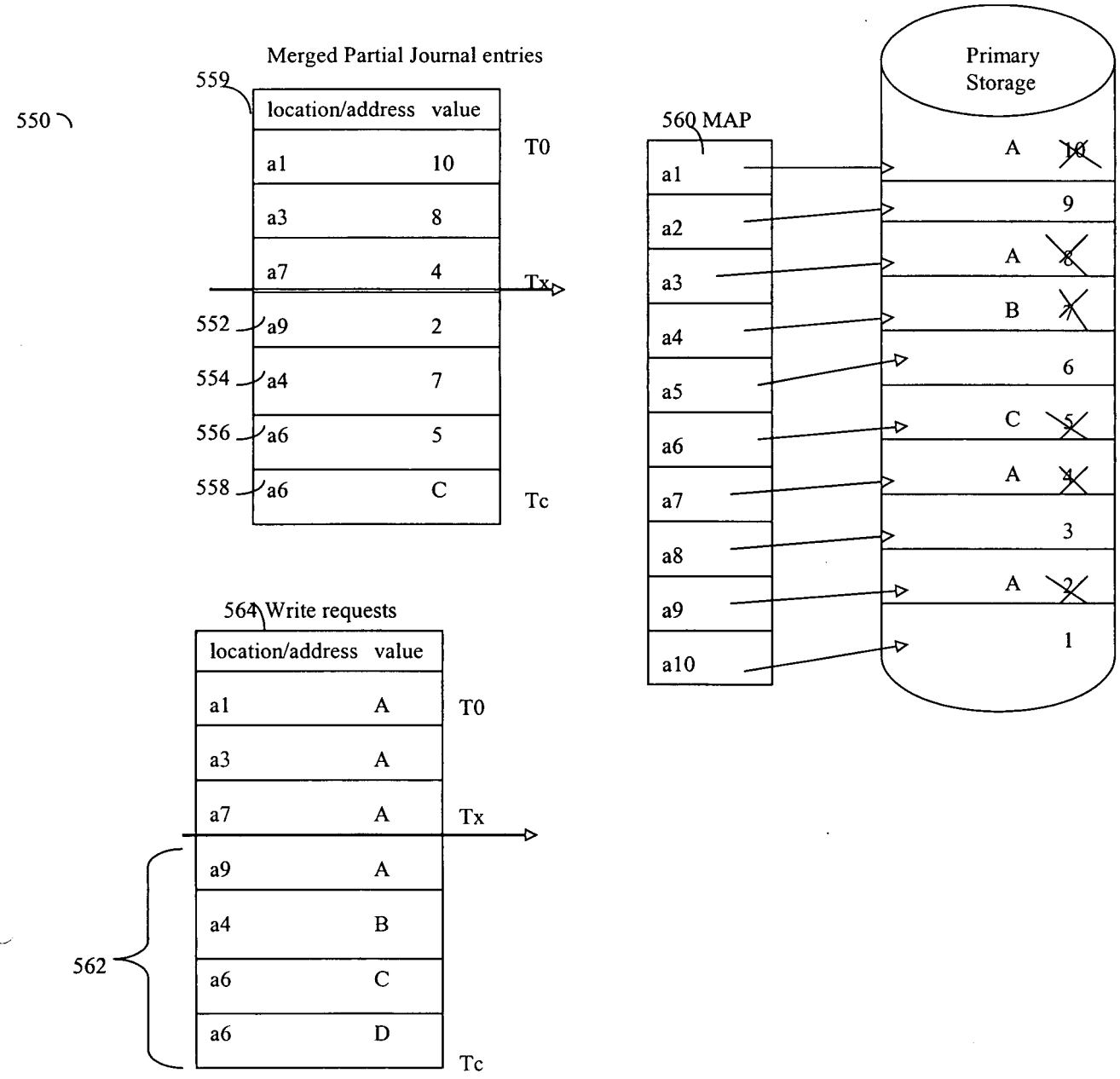

550
Merged Partial Journal entries
559
location/address value
a1 10
T0
a3 8
a7 4
Tx
552 a9 2
554 a4 7
556 a6 5
558 a6 C
Tc
560 MAP
a1
a2
a3
a4
a5
a6
a7
a8
a9
a10
Primary Storage
A 10
9
A 8
B 7
6
C 5
A 4
3
A 2
1
564 Write requests
location/address value
a1 A
T0
a3 A
a7 A
Tx
a9 A
a4 B
a6 C
a6 D
Tc
562

FIGURE 12

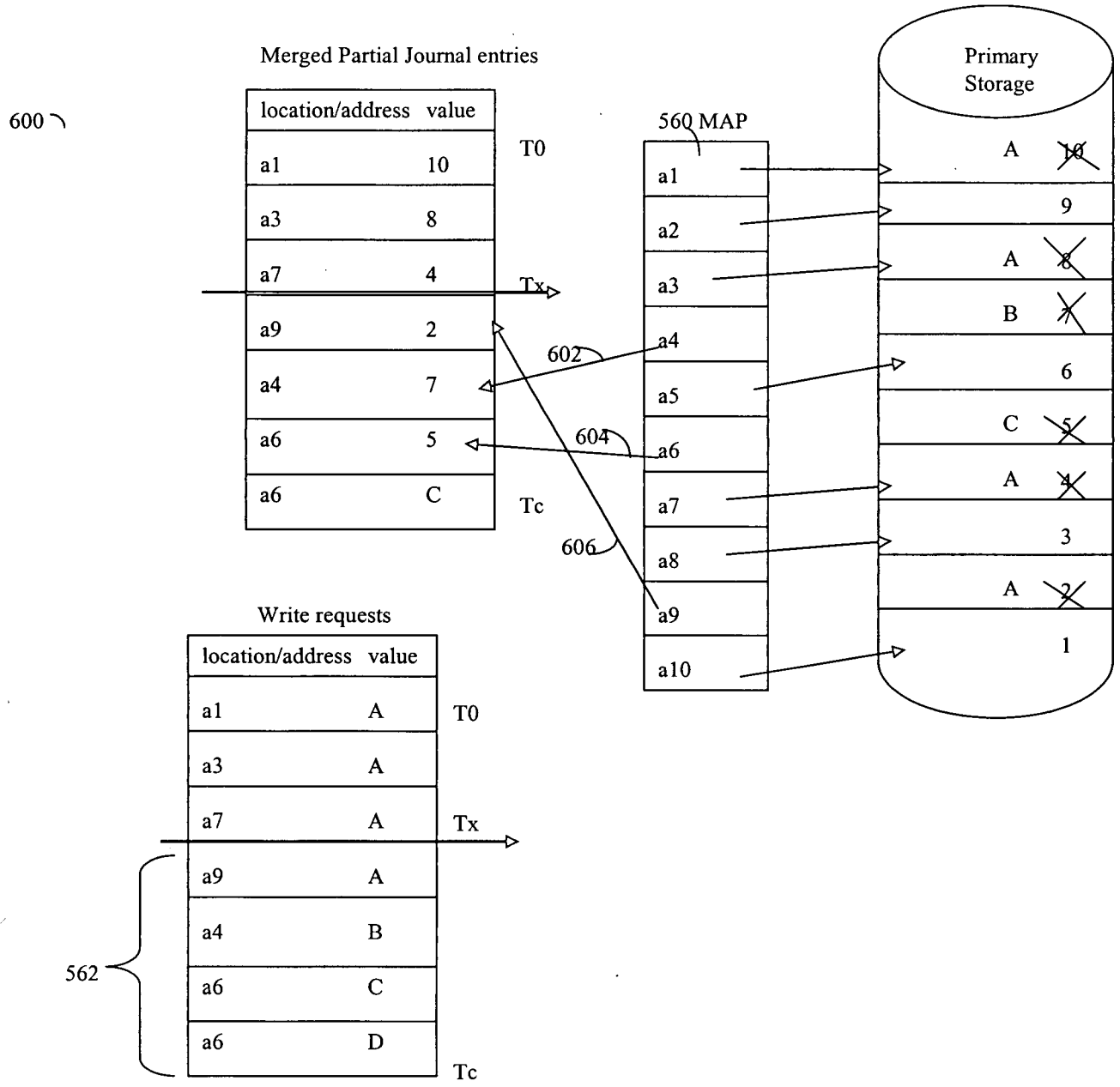

600
Merged Partial Journal entries
location/address value
a1 10
a3 8
a7 4
a9 2
a4 7
a6 5
a6 C
T0
Tx
Tc
602
604
606
560 MAP
a1
a2
a3
a4
a5
a6
a7
a8
a9
a10
Primary Storage
A 10
9
A 8
B 7
6
C 5
A 4
3
A 2
1
Write requests
location/address value
a1 A
a3 A
a7 A
a9 A
a4 B
a6 C
a6 D
T0
Tx
Tc
562

FIGURE 13

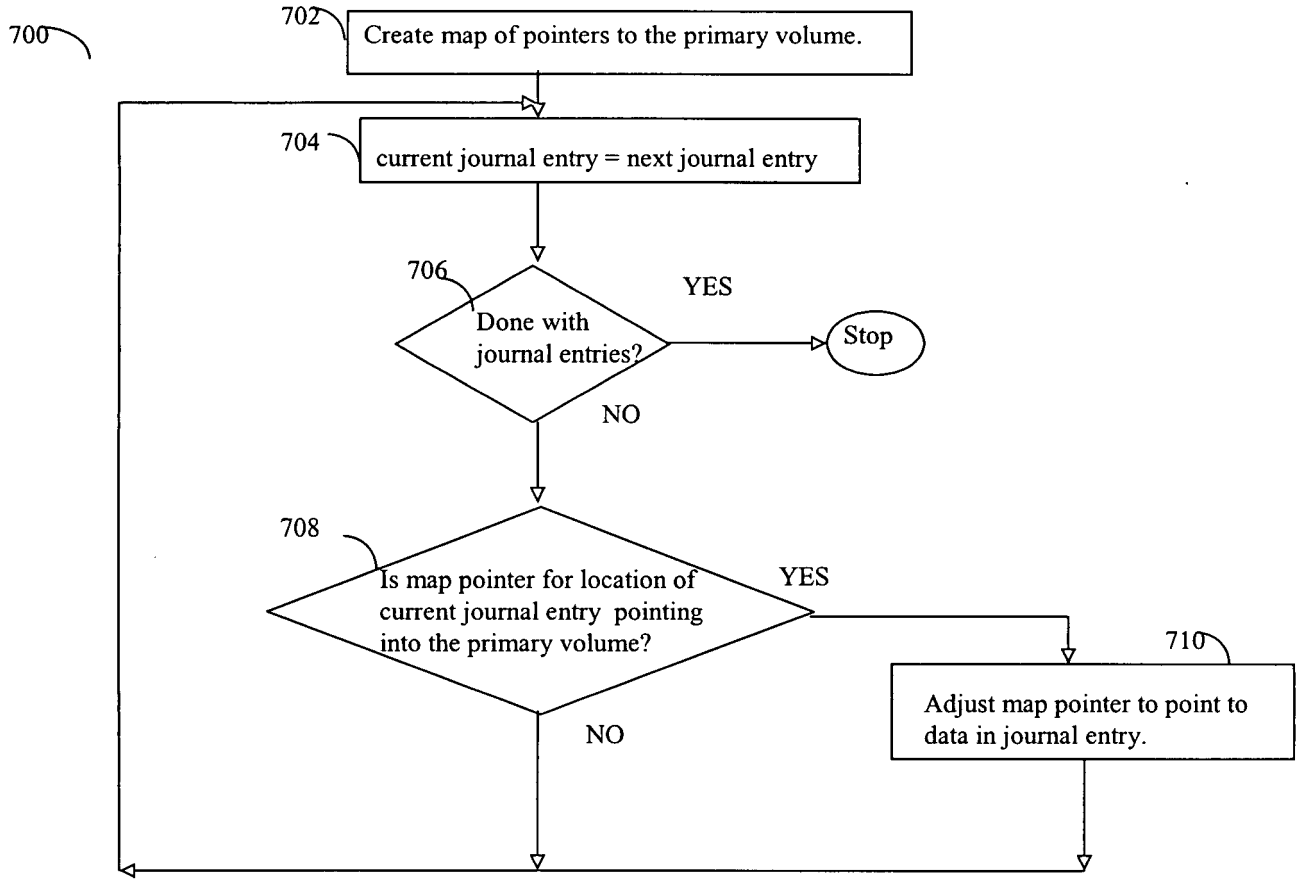

700
702
Create map of pointers to the primary volume.
704
current journal entry = next journal entry
706
Done with journal entries?
YES
Stop
NO
708
Is map pointer for location of current journal entry pointing into the primary volume?
YES
NO
710
Adjust map pointer to point to data in journal entry.

FIGURE 14

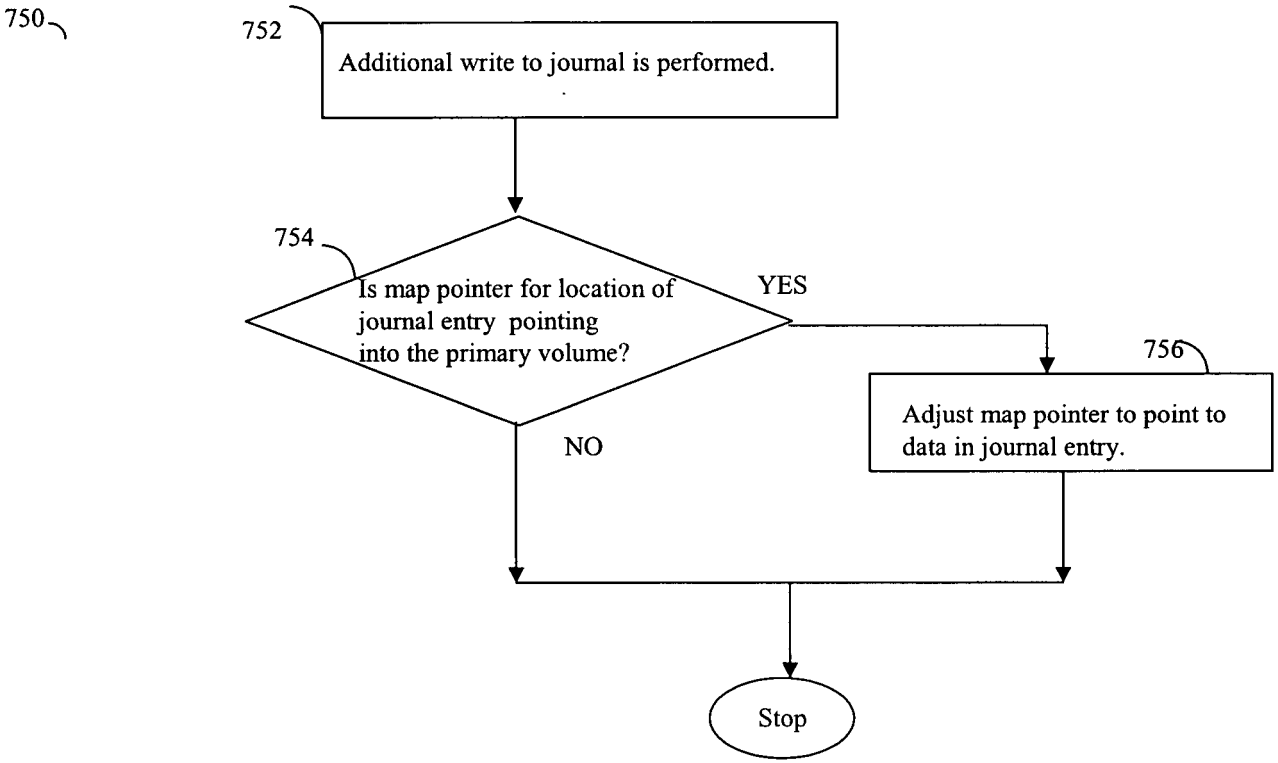

750
752
Additional write to journal is performed.
754
Is map pointer for location of journal entry pointing into the primary volume?
YES
NO
756
Adjust map pointer to point to data in journal entry.
Stop

FIGURE 15

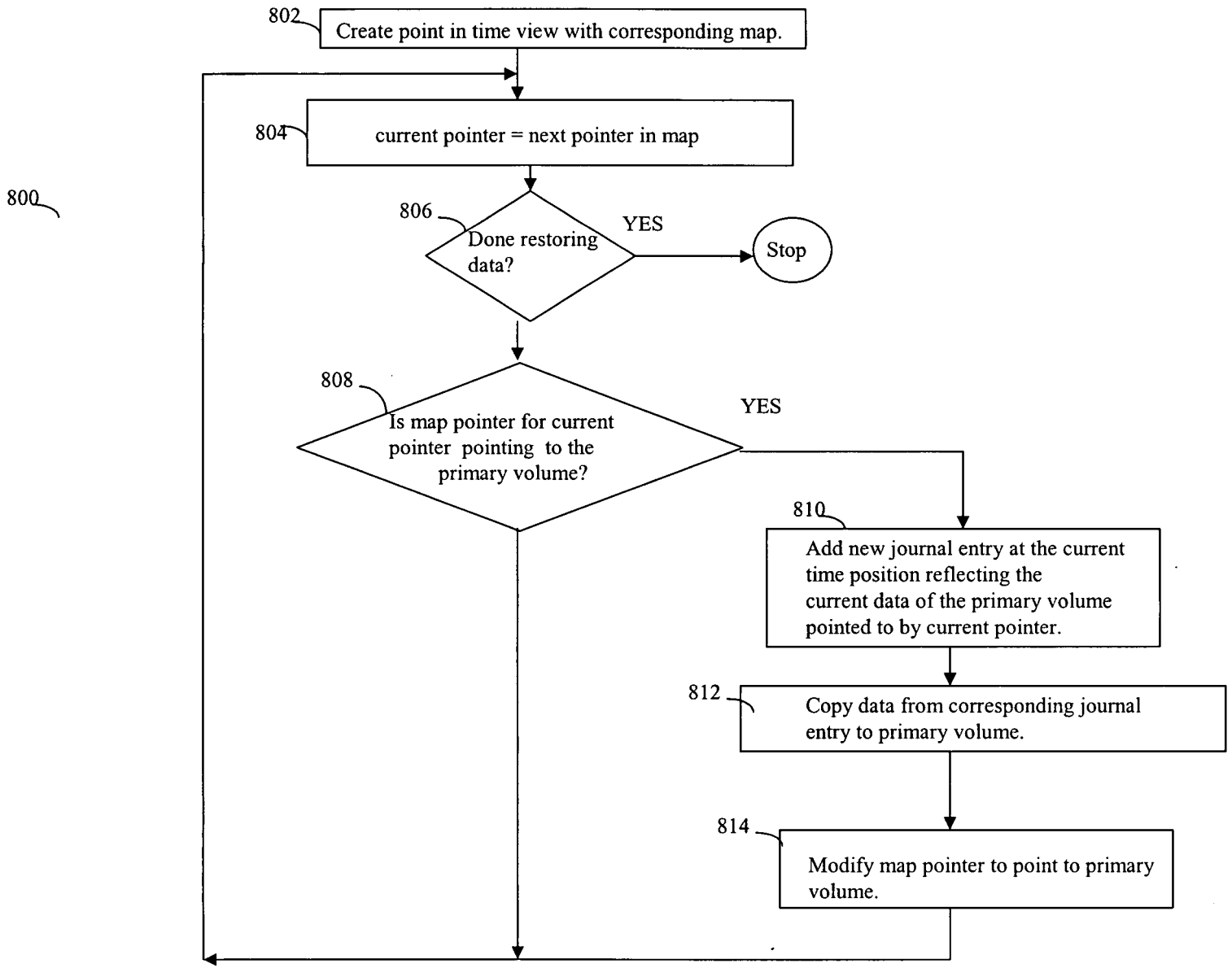

800
802
Create point in time view with corresponding map.
804
current pointer = next pointer in map
806
Done restoring data?
YES
Stop
808
Is map pointer for current pointer pointing to the primary volume?
YES
810
Add new journal entry at the current time position reflecting the current data of the primary volume pointed to by current pointer.
812
Copy data from corresponding journal entry to primary volume.
814
Modify map pointer to point to primary volume.

FIGURE 16